Performance relates more to design and maintenance than to physical deterioration

Low-volume foggers on fruit trees.

Evaluating low-volume irrigation systems for emission uniformity

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Since 1974, the acreage of permanent plantings in California irrigated with trickle or mister systems has increased more than five-fold from 75,000 to 400,000 acres. These systems offer the potential for highly efficient water use when water is uniformly discharged to each plant and irrigations are properly scheduled.

The research reported here was designed to evaluate the uniformity of discharge by low-volume systems in the field under normal operating conditions. In many cases, records of volume applied or even the total operating time were not available for the full season. Therefore, it was impossible to evaluate the seasonal water application efficiency, which includes the accuracy of scheduling. Rather, the emphasis was on measuring the uniformity of discharge per tree, irrespective of the adequacy of scheduling.

Procedure

Ideally, an irrigation system should distribute water in a perfectly uniform fashion throughout the field in which it is located. In practice, few systems operate with perfect uniformity and some are highly nonuniform. One means of measuring the uniformity of distribution utilizes the notion of emission uniformity of the low quarter, which expresses the variability as a ratio of the average discharge of the lowest 25 percent of the emitters to the average discharge of all emitters as follows:

Emission uniformity (EU) is defined as: $EU = 100 \times \frac{q_n}{q_a}$

where

q_n = average discharge from emitters in lowest 25% of discharge range

q_a = average discharge of all emitters

Thus, for example, an emission uniformity of 80 percent in a system where the average discharge is 1 gallon per tree per hour would reflect the fact that the lowest 25 percent of emitters are discharging 0.8 gallon per tree per hour on the average.

Limits on time and money usually prohibit measuring the discharges from all emitters. Instead, a sampling procedure is employed in which discharges are measured from some subset of emitters, and the emission uniformity of this subset (EU_{test}) is computed. The EU_{test} is then adjusted by an efficiency reduction factor (ERF), which measures differences in pressure throughout the systems to obtain an emission uniformity for the system as a whole as follows:

Emission uniformity (system) = emission uniformity (test) × efficiency reduction factor

In a typical trickle system, the major distributional components are the mainline, manifolds (submains), driplines (delivery hoses), and emitters (fig. 1). Each manifold and its associated driplines can be designated as a block. The sample uniformity of emission is measured within one block; pressure variations are measured between blocks. The sample emission uniformity is obtained by measuring the discharge volume from all emitters at 16 locations as denoted in figure 1. These measurements are used to compute the test emission uniformity.

Pressures are measured at the first and last dripline inlets on each manifold denoted by "×" in figure 1. The minimum pressures measured on each manifold are then used to compute the efficiency reduction factor according to the following formula:

$$ERF = \left[\frac{\text{low-quarter MLIP}}{\text{average MLIP}}\right]^X$$

where

MLIP = minimum lateral inlet pressure along a manifold (PSI)

Low-quarter MLIP = mean of MLIPs in lowest quarter of system (PSI)

Average MLIP = average of MLIPs from all manifolds (PSI)

× = emitter discharge exponent (obtained from manufacturer's specifications)

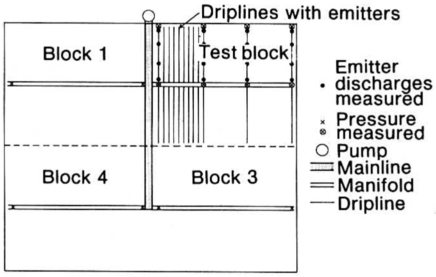

Fig. 1. Typical trickle system.

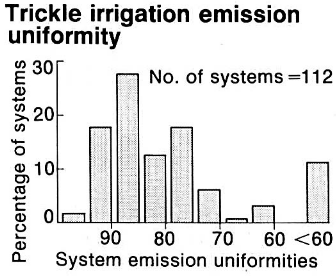

Fig. 2. 62 percent of systems were good to excellent.

Primary causes of low emission uniformities

Cause	Number of systems	Percent of systems
Excessive pressure differences	21	
Differences between manifolds	13	60
Differences within manifolds	4	20
Differences within driplines	4	20
Emitter variability not due to pressure	22	
Plugged emitters	11	50
Design and maintenance problems	11	50

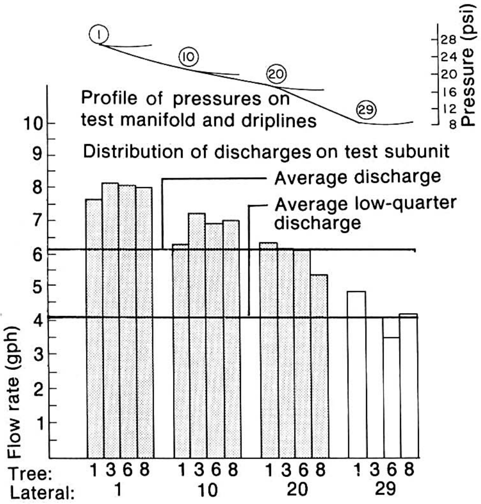

Fig. 3. Lowest quarter of discharges (non-shaded) in last dripline characterizes pressure loss within manifold.

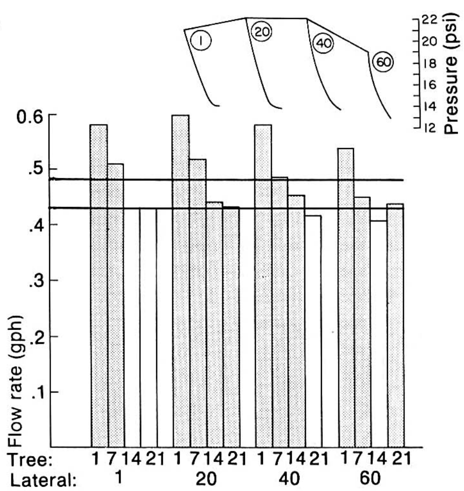

Fig. 4. Lowest quarter of discharges at ends of driplines indicates excessive pressure loss in driplines.

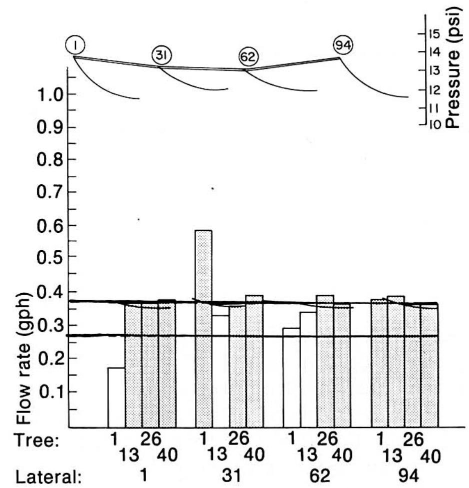

Fig. 5. When emitter plugging is a problem, lowest quarter of discharges tends to be randomly distributed.

The efficiency reduction factor is then used with the test emission uniformity to estimate the system emission uniformity. Pressures are also measured at the beginning and end of the lateral drip lines in the sample block. Although these pressures do not enter into the computation of emission uniformity, they may be necessary to diagnose precisely the cause of poor system uniformities. These pressure measurement points are denoted by ⊗ in figure 1.

Results

During the summer of 1981, this procedure was used to evaluate 112 low-volume systems on 40 ranches in the southern San Joaquin Valley. The sample included 15 different emission devices being used on nine perennial crops. The systems varied in age from 6 months to 10 years. For systems that have been in operation for one or more seasons, emission uniformities greater than 90 percent are regarded as excellent, between 80 and 90 percent as good, between 70 and 80 percent as fair, and below 70 percent as poor. Approximately 62 percent of the systems evaluated were operating in the good-to-excellent range, and 38 percent in the fair-to-poor range (fig. 2). The mean of all uniformities was 80.3 percent, and the standard deviation 13.3.

Results of a diagnostic analysis of systems with low uniformities (those in the fair and poor ranges) show that approximately half had problems associated with pressure differences and half had emitter variability problems caused by factors other than pressure (see table).

In most of the systems, the system emission uniformity was significantly lower (6 percent on the average) than the test emission uniformity. Differences of more than 2 percent between these uniformities are usually symptomatic of problems of pressure regulation between manifolds. Sixty percent of the pressure-related problems were attributable to poor pressure regulation. In many such cases, uniformities can be substantially improved by valve or regulator adjustments at manifold inlets.

Where large pressure losses on the driplines or within the manifolds are measured, certain patterns of emitter discharges typically appear. The appearance of the lowest quarter of discharges in the last dripline (fig. 3) is characteristic of large pressure losses within the manifold. Such losses, which are normally attributable to inadequate pipe sizing, accounted for 20 percent of the pressure-related problems. Excessive losses of pressure in driplines are usually indicated by the presence of the lowest quarter of discharges at the ends of driplines (fig. 4). These losses reflect excessive dripline length, and they accounted for the remaining 20 percent of the fair and poor uniformities associated with sharp differences in pressure.

Fifty percent of the low uniformities not associated with pressure problems were primarily the result of plugged emitters. Where plugging is a problem, the lowest quarter of emitter discharges tend to be randomly distributed (fig. 5). The remaining systems with low uniformities exhibited a high degree of variability caused by a mixture of design and maintenance problems to which emitter plugging may have contributed.

Most of the systems evaluated were between one and five years old. It is significant that there was no detectable relationship between the age of the system and emission uniformity. This suggests that performance over time is primarily a function of the adequacy of design and maintenance rather than physical deterioration of the system.

The results of these evaluations indicate that high emission uniformities are being achieved on the majority of fields irrigated with low-volume systems. However, a substantial number of the systems evaluated were not operating in the optimal range. The empirical results suggest that the emission uniformities of many, but not all, of these systems can be improved through careful attention to pressure regulation, emitter plugging, and the performance of filtration systems.

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Measuring irrigation flow.

Clogged screen.

Lepidopterous pests of tomatoes in southern desert valleys

Robert A. Van Steenwyk

California produces approximately 30 percent of the total U.S. production of fresh market tomatoes and approximately 85 percent of the processing tomatoes. Of the California total, the southern desert valleys produce about 10 percent of the fresh market and 5 percent of the processing tomatoes. The tomato fruitworm, tobacco budworm, and beet armyworm are major pests of both fresh market and processing tomatoes in the southern desert valleys, attacking the fruit and sometimes causing serious economic loss. The tomato fruitworm and beet armyworm also are major pests of tomatoes in other areas of California.

The tobacco budworm was found feeding on cotton in the Imperial Valley, California, in 1972. Before then it had been primarily a pest of ornamental plants. Possibly a new strain of tobacco budworm changed host preference or immigrated into southern California. In 1978, the tobacco budworm was found feeding on tomatoes.

Imperial Valley studies

Studies on seasonal fruitworm/budworm and beet armyworm development and the damage caused were conducted in the Imperial Valley, California, during the 1979 and 1980 growing seasons. In 1979, four fields of commercially grown fresh market bush tomatoes, three fields of commercially grown processing tomatoes, and two untreated, fresh market, bush tomato fields were used. In 1980 four commercial and one untreated field of fresh market, bush tomatoes were used. The commercial fields ranged from 35 to 100 acres, and the untreated fields were 1 acre each.

The fields were planted from mid-January to mid-February. Insecticides were applied to the commercial fields at the grower's discretion. In 1979, 6 to 7 (mean = 6.3) insecticide applications were made in the commercial processing fields and 3 to 15 (mean = 7.25) in the commercial fresh market tomatoes. In 1980, 2 to 5 (mean = 3.25) applications were made to the commercial fresh market tomato fields. The insecticides used were azinphosmethyl, methomyl, methamidophos, endosulfan, dimethoate, and mevinphos.

Each field was divided into four equal sections, and samples were taken from each section in both study years. The fields were sampled weekly for fruitworm/budworm eggs, beet armyworm larvae, and fruit damage.

Fruitworm/budworm egg populations were monitored weekly from March 14, 1979, and from March 20, 1980, until harvest: 12 meters of foliage per field (3 meters per section of the field) were inspected early in the growing season, decreasing to 4 meters per field (1 meter per section) as the season progressed. All eggs were reared to the adult stage in the laboratory for species identification.

Beet armyworm larval populations were monitored weekly from March 14, 1979, to harvest in the commercial fresh market fields, April 4, 1979, to harvest in both the commercial processing and untreated fields, and from March 27, 1980, to harvest in both the commercial and untreated fresh market tomato fields. Monitoring was done by shaking 12 meters of foliage per field (3 meters per section).

Fruit damage was evaluated weekly until commercial harvest by inspections of a minimum of 200 fruit early in the season and a maximum of 400 fruit per field late in the season (50 to 100 fruit per section). In the 1979 study, fruit sampling began on April 3 in the commercial fresh market tomato fields, May 3 in the commercial processing fields, and May 29 in the untreated fresh market fields. In 1980, sampling began on April 23 in the commercial fresh market fields and May 13 in the untreated fresh market field.

All fruit were classified as to the presence of fruitworm/budworm or beet armyworm larvae within the fruit, or internal and external damage without larvae present. Internal damage was that caused by a lepidopterous larva (primarily fruitworm/budworm) feeding within the fruit; external damage, by a lepidopterous larva (primarily beet armyworm) feeding on the outside. All fruitworm/budworm larvae found feeding within the fruit were reared to adults for species identification.

Results and discussion

During the spring of 1979, in all commercial and untreated fields, fruitworm/budworm females had two peak egg-laying periods. One peak occurred on the April 18-25 sampling dates and the other at the end of the growing season. The first egg-laying period was soon after moth emergence from overwintering diapause and averaged from 0.2 egg per meter of foliage in the untreated fresh market fields to 0.8 in the commercial processing fields. In Arizona, fruitworm/budworm moths have been observed emerging from diapause from March through May with a peak in late April.

The second egg-laying period, approximately six weeks after the first